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Economic Effects of the Red Grouper Interim Rule Policies on the Private and Charter Boat Anglers in the Gulf of Mexico, including the Addendum on the Economic Effects of the 2005 Reef Fish Fishery Regulatory Amendment for Red Grouper

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David W. Carter
National Marine Fisheries Service
Southeast Fisheries Science Center
Miami Laboratory
75 Virginia Beach Drive
Miami, FL 33149

Email: david.w.carter@noaa.gov

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Abstract: *This report documents the economic analysis of management alternatives proposed in 2005 for the recreational sector of the red grouper fishery in the Gulf of Mexico. The economic effects are estimated for private and charter boat anglers.*

1. Introduction

In 2003 and 2004 the recreational sector exceeded its allocation of the allowable catch of red grouper specified in Secretarial Amendment 1 to the Reef Fish Fishery Management Plan in the Gulf of Mexico (GOM). The GOM Fishery Management Council has requested that NOAA's National Marine Fisheries Service develop an interim rule with management measures that will reduce the chances of the recreational allocation being exceeded again in 2005 (Strelcheck 2005). Table 1 summarizes the twenty-two management alternatives proposed for the recreational sector. This report describes the economic analysis of these management alternatives for private and charter boat anglers.

2. Methods

This section describes the methods used to estimate the economic effects of the proposed management alternatives on saltwater angling activity in the GOM. Only private and charter boat modes are considered and all analyses are conducted with data from the Marine Recreational Fisheries Statistics Survey (MRFSS).[1] Therefore, the economic effects of the interim rule are only estimated for anglers fishing in States covered by the MRFSS.[2]

[1] Red grouper are rarely caught from the shore. Head boat fishing data is available from the NMFS Head Boat Survey. This data is not considered in the economic analysis given the relatively small effect of the Red Grouper Interim Rule on head boat harvest suggested by a recent biological analysis (Strelcheck 2005).

[2] Texas is not covered by the MRFSS in the GOM.

The general approach considers the reduction in keep of red grouper and fish in the GOM snapper-grouper complex (see Appendix A) that would have occurred if the proposed interim rule policies were in place during 2003 and 2004. Figure 1 shows that 2004 represents a year with relatively large recreational keep of red grouper whereas 2003 is indicative of a year with relatively small keep. Therefore, the range of effects of the policies implemented in these two years should bound the possible effects of the policies implemented in 2005.

Three types of policies are evaluated: red grouper daily bag limits, aggregate grouper bag limits, and grouper fishery closures. The economic analysis assumes that the changes in value from these policies are manifest in changes in the number of fish kept, rather than in fish caught or the number of trips taken.[3] Furthermore, the effects are valued in terms of changes in keep from the GOM snapper-grouper complex by anglers who targeted these species. This sub-population of all anglers in the GOM was selected to be consistent with the most recent economic analysis of marine recreational fishing in the Southeastern U.S. (Haab, et al. 2001).[4] Table 2 shows the average estimated value by State of a one fish increase in keep of species from the GOM snapper-grouper complex. Economic value estimates are not available for individual snapper-grouper species.[5]

[3] This approach also limits the scope of analysis to individual anglers and does not consider the effects on owners of the for-hire operations. It is appropriate to the extent that policy changes *do not* alter angler effort or targeting behavior during the interim rule. There is not sufficient economic information to incorporate effort or targeting dynamics into the present analysis. However, the measurement of effort responses to policy and landings changes is an active area of research in the Southeast (e.g., Carter and Letson 2004).

[4] The estimates of value in Table 2 are for private boat anglers, but are applied to both private and charter boat fishing for the present analysis.

[5] For example, a search of the Southeast Recreational Fisheries Social Science Literature Database (https://grunt.sefsc.noaa.gov/P_SocScienceLiterature/index.jsp) only finds three studies that considered red grouper. None of these studies contains economic value information.

The economic values per fish are applied to the reductions in snapper-grouper keep expected in each State with the proposed interim rule alternatives. Thus, the calculation of these reductions is an important of the economic analysis. The approach used for this analysis follows the methods used in Strelcheck (2005) and Brooks (2003, 2004) to calculate expected harvest changes with MRFSS data. Specifically, each MRFSS intercept trip in 2003 and 2004 is subjected to the proposed interim policies and the change in expected keep is recorded for red grouper, the aggregate grouper bag, and the snapper-grouper complex.

Let K_rg be the keep of red grouper for an individual angler. The keep with a red grouper bag limit of b_rg is given by

(1) $K\_rg[b\_rg] = b\_rg\ (1\text{-}D\_rg) + K\_rg \cdot D\_rg$

where D is an indicator that equals one if $K\_rg \leq b\_rg$ and zero otherwise. All else equal, the corresponding keep of fish in the aggregate grouper bag, K_gb, is

(2) $K\_gb[b\_rg] = K\_gb - K\_rg + K\_rg[b\_rg]$.

An aggregate grouper bag limit, b_gb, is modeled the same way as the red grouper bag. Therefore, the effect of a red grouper and aggregate grouper limit on the aggregate grouper bag can be expressed as

(3) $K\_gb[b\_rg, b\_gb] = b\_gb \cdot (1\text{-}D\_gb) + K\_gb[b\_rg] \cdot D\_gb$

where D_gb is an indicator that equals one if $K\_gb \leq b\_gb$ and zero otherwise. Note that this formulation assumes that the angler complies with the bag limits sequentially. That is, they exhaust the red grouper bag limit first and then the aggregate grouper bag limit.

A seasonal limit on the keep of groupers in the aggregate bag has the effect of zeroing any keep of these species during the regulated time period. In combination with red grouper and aggregate grouper bag limits, a seasonal closure appears as

(4) $K\_gb[b\_rg, b\_gb, S\_gb] = \{b\_gb \cdot (1\text{-}D\_gb) + K\_gb[b\_rg] \cdot D\_gb\} \cdot S\_gb$

where *S_gb* is an indicator that equals one if the period in which the trip occurs is open and zero otherwise. This expression can be used to calculate the keep per trip of species in the snapper-grouper complex in the presence of the red grouper bag limit, the aggregate grouper bag limit, and the aggregate grouper closed season as

(5) $K\_sg[b\_rg, b\_gb, S\_gb] = K\_sg - K\_gb + K\_gb[b\_rg, b\_gb, S\_gb]$.

The change in snapper-grouper keep per trip with the policies is simply

(6) $K\_sg[b\_rg, b\_gb, S\_gb] - K\_sg \equiv K\_gb[b\_rg, b\_gb, S\_gb] - K\_gb$

if there is no change in the keep of other species in the snapper grouper complex for this trip.

The mean reduction in keep per trip for each state/mode/wave combination is found by averaging over expression (6) for each stratum using the angler group of interest. Again, to be consistent with the values presented in Table 2, we are interested in anglers who target species in the snapper-grouper complex. Table 3 shows the disposition of private and charter boat MRFSS intercepts in the GOM during 2003 and 2004. The snapper-grouper target trip statistics are compared with the statistics for the group of trips that caught red grouper. This latter group is used as the basis of the analysis of Red Grouper Interim Rule harvest reductions (Strelcheck 2005). Note that the number of contributors shown refers to the anglers who contributed to keep (MRFSS TYPE A) that could not be separated. For the bag limit analyses, the TYPE A catch of these records was divided by the number of contributors to calculate an average keep per contributor. This average keep was subjected to the bag limits and the calculated reductions where then multiplied by the number of contributors to obtain the total reduction in keep per trip.

The total estimated number of snapper-grouper target trips, *T_sgt_E*, in each state/mode/wave strata can be calculated as follows

(7) $T\_sgt\_E = (T\_sgt/T\_all)/T\_all\_E$

where *T_all* is the number of MRFSS intercept trips in the strata, *T_sgt* is the number of those trips that targeted snapper-grouper species, and *T_all_E* is the total number of trips estimated for the strata. Weighting by total estimated trips in each stratum before summing or averaging to higher strata addresses the possible non-random distribution of trips across stratum (NMFS 1999, Chapters 4 and 7). This same calculation can be performed to get estimated trips for other groups. Table 4 shows the estimated target and catch trips for red grouper, the aggregate grouper bag, and the snapper-grouper complex. Note that these totals only cover the interim rule months from July to December or MRSS waves four through six.

3. Results and Discussion

The economic effects of the interim rule on private and charter boat anglers using 2003 and 2004 MRFSS data are shown in Table 5 and Table 6, respectively.[6] The column headings the Tables are defined as follows:

aff_rgb	Intercept trips affected by the red grouper bag limit
aff_gbb	Intercept trips affected by the aggregate grouper bag limit
aff_gbs	Intercept trips affected by the aggregate grouper closed season
Trips_rgbE	Estimated trips affected by the red grouper bag limit
Trips_gbbE	Estimated trips affected by the aggregate grouper bag limit
Trips_gbsE	Estimated trips affected by the aggregate grouper closed season
est_sgr	Estimated change in snapper-grouper keep
val_sgr	Estimated change in economic value

The first three columns are the number of intercepted trips affected by each type of regulation and the next three columns are the corresponding estimated trips calculated using a formula similar to expression (7). The estimated change in snapper grouper keep shown in the *est_sgr*

[6] Results are also available by mode for each year or in combination.

column is based on an average of expression (6) over snapper-grouper target trips by state/mode/wave strata. This average is then multiplied by a weighted estimate of total snapper-grouper targeted trips for the corresponding strata. The weighted estimates for each state/mode/wave strata are then summed to get the total estimated change in snapper-grouper keep. The values reported in Table 2 are applied at the state strata before summing to calculate the total change in economic value reported in the *val_sgr* column. The change in value relative to the status quo (Action 1, Alternative 1) is a measure of the *relative* economic effect of each alternative.

It is important to emphasize that the reported effects are appropriate measures of *relative* changes in the recreational fishery anticipated with the Red Grouper Interim Rule. The absolute value of the effects should be viewed with caution given the following assumptions used in the analysis:

- The fishery in 2003 or 2004 accurately represents the fishery in 2005.
- Effort is does not change in response to policy changes.
- Catch rates of snapper-grouper species do not change as a result of the interim rule or anglers do not value these changes, i.e., only changes in keep rates are valuable.
- The value of a one fish decrease in keep of snapper-grouper species is the same as the value of a one unit increase.
- The value of all species in the snapper-grouper complex is the same on average.
- Charter boat anglers value snapper-grouper species the same as private boat anglers.
- The value of incidental (non-targeted) keep of snapper-grouper species is unchanged by the interim rule.

There are additional technical assumptions in this analysis and others that warrant a prudent use of the both the relative and absolute values of the effects reported. More research is needed on the economics of recreational fisheries in the Southeastern U.S. to relax these assumptions in future analyses.

References

Brooks, Elizabeth. 2003. *An Evaluation of Bag Limits and Minimum Size Limits for Managing the Vermillion Snapper Recreational Fishery.* NOAA Southeast Fisheries Science Center Sustainable Fisheries Division Contribution No. SFD-.

Brooks, Elizabeth. 2004. *An Evaluation of Adding Vermillion Snapper to the Aggregate Snapper Bag Limit and a Vermillion Snapper Bag Limit of 10 for Recreational Fishery Management.* NOAA Southeast Fisheries Science Center Sustainable Fisheries Division Contribution No. SFD-2004-002.

Carter, David W. and David Letson. 2004. *Recreational Fishing Effort, Harvest, and Climate: Red Snapper in the Gulf of Mexico.* NOAA Southeast Fisheries Science Center Social Science Research Group Working Paper Series SEFSC-SSRG-06.

Haab, Whitehead, and McConnell. 2001. *The Economic Value of Marine Recreational Fishing in the Southeast United States 1997 Southeast Economic Data Analysis.* NOAA Technical Memorandum NMFS-SEFSC-466.

NMFS. 1999. *Marine Recreational Fisheries Statistics Survey (MRFSS) Data User's Manual.* Available at: www.st.nmfs.gov/st1/recreational/pubs/data_users/.

Strelcheck, Andy. 2005. *Red Grouper Interim Rule: Bag Limit and Seasonal Closure Analyses, with Associated Impacts on Other Groupers.* National Marine Fisheries Service Southeast Regional Office, April 26.

Table 1. Proposed Management Alternatives for the Recreational Red Grouper Fishery

Action	Alternative	Proposed Red Grouper Bag Limit (fish)	Proposed Grouper Bag Limit (fish)	Proposed Grouper Closed Season
1. Red Grouper Management Alternatives	1	2	5	None
	2	1	5	None
	3a	1	5	Oct-Dec
	3b	1	5	Sep-Dec
	3c	1	5	Aug-Sep
	3d	1	5	Aug-Nov
	4	1	5	Jul-Dec
2. Aggregate Grouper Management Alternatives	2	1	4	None
	3	1	3	None
	4	1	2	None
	2a	1	4	Oct-Dec
	3a	1	3	Oct-Dec
	4a	1	2	Oct-Dec
	2b	1	4	Sep-Dec
	3b	1	3	Sep-Dec
	4b	1	2	Sep-Dec
	2c	1	4	Aug-Sep
	3c	1	3	Aug-Sep
	4c	1	2	Aug-Sep
	2d	1	4	Aug-Nov
	3d	1	3	Aug-Nov
	4d	1	2	Aug-Nov

Table 2. Value of Unit increase in Catch and Keep of Snapper-Grouper by State*

State	$1997	$2004**
Alabama	0.23	0.27
Louisiana	1.04	1.22
Mississippi	0.35	0.41
West Florida	3.52	4.14

Source: Haab, Whitehead, and McConnell. (2001, Table 5-8).

*The values are for snapper-grouper species that were kept by private boat anglers who targeted species in the snapper-grouper complex.
**Adjusted to $2004 with the factor 1.18 (188.9/160.5) based on the 1997 (160.5) and 2004 (188.9) values of the U.S. CPI (BLS Series CUUR0000SA0, U.S. Consumer Price Index-All Urban Consumers, All items, 1982-84=100).

Table 3. Disposition of the Red Grouper Recreational Keep in the Gulf of Mexico: 2003-2004

	Target Snapper-Grouper		Catch Red Grouper		
	No	Yes	No	Yes	Total
			--Keep per Trip--		
N	41,456	2,842	41,392	2,906	44,298
Sum	3,168	1,105	-	4,273	4,273
Mean	0.08	0.39	-	1.47	0.10
Std	0.77	1.60	-	3.01	0.85
Min	-	-	-	-	-
Max	34.00	37.00	-	37.00	37.00
			--Contributors--		
N	41,456	2,842	41,392	2,906	44,298
Sum	61,234	6,939	57,722	10,451	68,173
Mean	1.48	2.44	1.39	3.60	1.54
Std	1.35	2.56	1.17	3.03	1.48
Min	1.00	1.00	1.00	1.00	1.00
Max	27.00	31.00	31.00	26.00	31.00
			--Keep per Contributor--		
N	41,456	2,842	41,392	2,906	44,298
Sum	723	282	-	1,005	1,005
Mean	0.02	0.10	-	0.35	0.02
Std	0.18	0.39	-	0.69	0.20
Min	-	-	-	-	-
Max	9.00	7.40	-	9.00	9.00

Source: MRFSS Intercepts for Private and Charter Boat Anglers (2004 as of 2/2005)

Table 4. Private and Charter Boat Effort in the Gulf of Mexico, 2003-04, Waves 4 - 6

	2003	2004	2003	2004
	--Intercepts--		*--Estimates--*	
Red Grouper Catch Trips	625	783	298,454	294,991
Grouper Bag Catch Trips	1,323	1,406	766,331	630,149
Snapper-Grouper Catch Trips	2,420	2,342	1,542,851	1,172,677
Red Grouper Target Trips	46	138	28,065	78,523
Grouper Bag Target Trips	257	341	182,801	193,442
Snapper-Grouper Target Trips	702	735	480,755	438,116
Total Trips	9,806	11,017	8,097,339	7,195,932

Source: MRFSS (2004 as of 2/2005) and Author's calculations.

Table 5. Economic Effects of the Interim Rule on Private and Charter Boat Anglers: 2003

aff_rgb	aff_gbb	aff_gbs	trips_rgbE	trips_gbbE	trips_gbsE	est_sgr		val_sgr	action	scenario
4	4	-	483	453	-	9,199	$	38,083	1	Alt1
18	4	-	7,075	453	-	20,853	$	86,331	1	Alt2
18	4	233	7,075	453	158,995	81,445	$	328,102	1	Alt3a
18	4	391	7,075	453	273,257	113,347	$	449,286	1	Alt3b
18	4	317	7,075	453	215,300	78,395	$	304,439	1	Alt3c
18	4	550	7,075	453	374,295	138,988	$	546,211	1	Alt3d
4	4	702	483	453	480,755	180,181	$	686,364	1	Alt4
4	4	-	483	453	-	9,199	$	38,083	2	Alt1
18	8	-	7,075	907	-	24,780	$	102,590	2	Alt2
18	8	233	7,075	907	158,995	84,190	$	339,465	2	Alt2a
18	8	391	7,075	907	273,257	115,004	$	456,144	2	Alt2b
18	8	317	7,075	907	215,300	80,481	$	313,077	2	Alt2c
18	8	550	7,075	907	374,295	139,891	$	549,951	2	Alt2d
18	12	-	7,075	3,122	-	31,679	$	131,152	2	Alt3
18	12	233	7,075	3,122	158,995	87,599	$	353,577	2	Alt3a
18	12	391	7,075	3,122	273,257	116,961	$	464,249	2	Alt3b
18	12	317	7,075	3,122	215,300	85,176	$	332,514	2	Alt3c
18	12	550	7,075	3,122	374,295	141,096	$	554,939	2	Alt3d
18	25	-	7,075	10,495	-	53,752	$	222,532	2	Alt4
18	25	233	7,075	10,495	158,995	98,941	$	400,534	2	Alt4a
18	25	391	7,075	10,495	273,257	123,884	$	492,909	2	Alt4b
18	25	317	7,075	10,495	215,300	100,046	$	394,073	2	Alt4c
18	25	550	7,075	10,495	374,295	145,235	$	572,075	2	Alt4d

Table 6. Economic Effects of the Interim Rule on Private and Charter Boat Anglers: 2004

aff_rgb	aff_gbb	aff_gbs	trips_rgbE	trips_gbbE	trips_gbsE	est_sgr	val_sgr	action	scenario
9	8	-	3,721	2,047	-	16,570	$ 68,600	1	Alt1
32	8	-	11,527	2,047	-	42,655	$ 176,590	1	Alt2
32	8	282	11,527	2,047	146,171	158,773	$ 621,154	1	Alt3a
32	8	334	11,527	2,047	165,129	173,916	$ 683,316	1	Alt3b
32	8	223	11,527	2,047	145,493	142,954	$ 580,579	1	Alt3c
32	8	505	11,527	2,047	291,664	259,073	$ 1,025,143	1	Alt3d
9	8	735	3,721	2,047	438,116	312,333	$ 1,234,703	1	Alt4
9	8	-	3,721	2,047	-	16,570	$ 68,600	2	Alt1
32	14	-	11,527	4,089	-	54,158	$ 224,213	2	Alt2
32	14	282	11,527	4,089	146,171	165,200	$ 647,761	2	Alt2a
32	14	334	11,527	4,089	165,129	179,460	$ 706,268	2	Alt2b
32	14	223	11,527	4,089	145,493	151,148	$ 614,503	2	Alt2c
32	14	505	11,527	4,089	291,664	262,191	$ 1,038,051	2	Alt2d
32	21	-	11,527	5,795	-	73,061	$ 302,471	2	Alt3
32	21	282	11,527	5,795	146,171	175,650	$ 691,024	2	Alt3a
32	21	334	11,527	5,795	165,129	188,523	$ 743,788	2	Alt3b
32	21	223	11,527	5,795	145,493	163,583	$ 665,984	2	Alt3c
32	21	505	11,527	5,795	291,664	266,172	$ 1,054,536	2	Alt3d
32	37	-	11,527	11,595	-	104,900	$ 434,284	2	Alt4
32	37	282	11,527	11,595	146,171	195,267	$ 772,239	2	Alt4a
32	37	334	11,527	11,595	165,129	204,105	$ 808,298	2	Alt4b
32	37	223	11,527	11,595	145,493	181,806	$ 741,424	2	Alt4c
32	37	505	11,527	11,595	291,664	272,173	$ 1,079,378	2	Alt4d

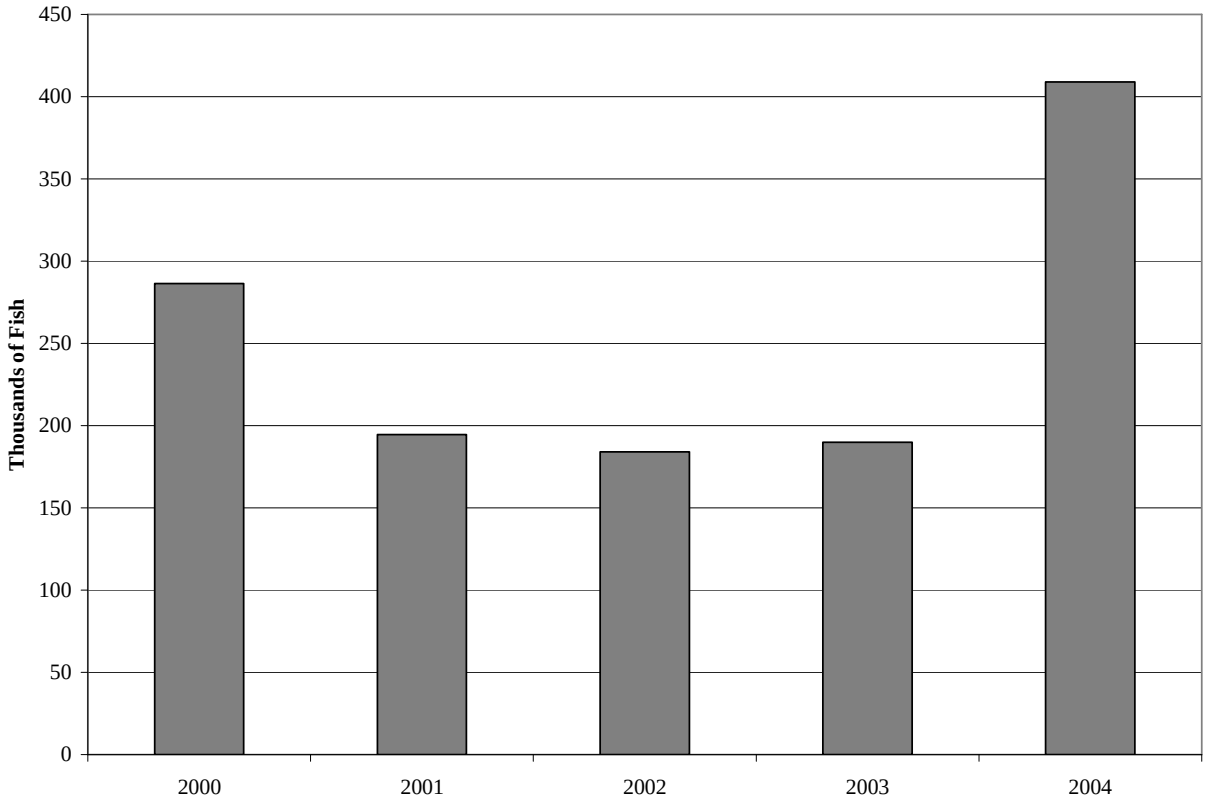

Figure 1. Private and Charter Boat Keep of Red Grouper in the Gulf of Mexico

Source: MRFSS Estimates (2004 as of 2/2005).

Appendix A. Species in the Gulf of Mexico Snapper Grouper Complex

Common Name	MRFSS Code
sand perch	8835021002
dwarf sand perch	8835021005
Jewfish	8835020401
rock hind	8835020402
speckled hind	8835020404
yellowedge grouper	8835020405
red hind	8835020406
red grouper	8835020408
misty grouper	8835020409
warsaw grouper	8835020410
snowy grouper	8835020411
Nassau grouper	8835020412
Gag	8835020501
black grouper	8835020502
yellowmouth grouper	8835020504
Scamp	8835020505
yellowfin grouper	8835020506
blackline tilefish	8835220102
Tilefish	8835220201
greater amberjack	8835280101
lesser amberjack	8835280102
banded rudderfish	8835280104
queen snapper	8835360301
cubera snapper	8835360101
gray snapper	8835360102
mutton snapper	8835360103
schoolmaster	8835360104
blackfin snapper	8835360106
red snapper	8835360107
dog snapper	8835360109
mohogany snapper	8835360110
lane snapper	8835360112
silk snapper	8835360113
yellowtail snapper	8835360401
wenchman	8835360701
vermilion snapper	8835360501
hogfish	8839010901
gray triggerfish	8860020202
queen triggerfish	8860020201
almaco jack	8835280803
goldface tilefish	8835220105
anchor tilefish	8835220103

Appendix B. Species in the Gulf of Mexico Aggregate Grouper Bag

Common Name	MRFSS Code
gag	8835020501
red grouper	8835020408
black grouper	8835020502
yellowfin grouper	8835020506
scamp	8835020505
yellowmouth grouper	8835020504
rock hind	8835020406
red hind	8835020406
yellowedge grouper	8835020405
misty grouper	8835020409
snowy grouper	8835020411
warsaw grouper	8835020410
speckled hind	8835020404

Addendum on the Economic Effects of the 2005 Reef Fish Fishery Regulatory Amendment for Red Grouper on the Private and Charter Boats in the Gulf of Mexico

This addendum describes the methods used to evaluate the economic effects on the anglers from private and charter boats of the 2005 regulatory amendment to the Gulf of Mexico reef fish management plan for red grouper. The policy alternatives proposed in the 2005 red grouper regulatory amendment (RA) are listed in Table 1a.[1] Note that minimum size, vessel and passenger limits have been added for consideration. Therefore, the methodology that was used to evaluate the Red Grouper Interim Rule (IR) has to be expanded to handle the affects of changes in these additional policies. The evaluation of the RA uses this expanded methodology along with updated data.[2] Additional results covering the effects over an entire year, rather than the interim period, are also reported. The updated disposition of red grouper recreational keep from the MRFSS during 2003 and 2004 is shown in Table 2a.

Methods for Minimum Size Limits

Distributions of total lengths of measured red grouper keep by the MRFSS sample of anglers in the Gulf of Mexico during 2003 and 2004 are shown in Figure 1a. The shape of these distributions reflects the 20" minimum size limit for red grouper that has been in place since 1990. It should be noted that this sample of lengths is based on a subset of the trips that caught red grouper shown in Table 3a. Specifically, only a fraction of those who caught red grouper actually kept fish and only a portion of these fish were actually measured by MRFSS interviewers.

[1] The alternatives are based on a list distributed on 8/15/2005 by Stu Kennedy at NMFS/SERO.

[2] The MRFSS data for 2004 used for the interim rule was updated during 5/2005.

Using the notation from Section 2 of the IR document, denote the number of red grouper measured as K_rg_1 and the count of those unmeasured as K_rg_0, so that the total number of observed red grouper kept per angler is

(A1) $$K\_rg = K\_rg_1 + K\_rg_0 .$$

The red grouper minimum size limit constrains the number of fish that can be kept by each angler as follows

(A2) $$\begin{aligned} K\_rg[m\_rg] &= \{1 - p(m\_rg)\} \cdot K\_rg \\ &= \{1 - p(m\_rg)\} \cdot K\_rg_1 + \{1 - p(m\_rg)\} \cdot K\_rg_0 \end{aligned}$$

where $p(m\_rg)$ denotes the proportion of kept fish that are below the minimum size, m_rg. This formulation assumes that the proportion of fish that are less than the minimum size is the same for both measured and unmeasured fish. Thus, the proportion below the minimum size is calculated for each angler using the measured fish, K_rg_1, and applied in equation (A2) to calculate the keep of red grouper with each minimum size. The alternatives that consider minimum size limits in conjunction with other policies are evaluated using $K\_rg[m\_rg]$ as the starting point, i.e., in place of K_rg in expression (1) of Section 2 or expression (A3) below.

Methods for Vessel and Passenger Limits

Vessel limits define the maximum number of red grouper that can be kept per "vessel" and passenger limits define the number of fish that can be kept per passenger on for-hire vessels with a Certificate of Inspection (COI) permit from the U.S. Coast Guard. For the purposes of this analysis, the number of anglers per vessel or passengers is assumed to be the number of members in the fishing party. Also, it is assumed that only charter boat trips with more than six party members are affected by the COI passenger limits.

Recall that the keep per angler quantity (*K_rg*) used in the IR analysis was defined as the MRFSS Type A keep divided by the number of contributors. The definition of *K_rg* has been modified for the RA analysis as the Type A catch divided by the number of party members. All party members may not have contributed to Type A so that the RA definition of *K_rg* will always be less than or equal to the IR definition.

A vessel limit can be converted to a restriction on the number of (average) keep per person by dividing the limit amount by the number of party members. The passenger limit can also be expressed as a limit per party member. For example, a limit of 1 fish per two passengers is (statistically) equivalent to 0.5 fish per passenger. In this way, the vessel limits, passenger limits, and bag limits can be viewed as synonymous constraints on the average keep per party member.

If *v_rg/party* and *b_rgc* are, respectively, the effective red grouper vessel limit and passenger limit per individual, then expression (1) in the IR analysis can be redefined to account for the effect of all policies as follows

$$
\begin{aligned}
& K\_rg\left[m\_rg,\ b\_rg,\ v\_rg,\ b\_rgc\right] \\
(A3) \qquad & = D\_rgbvc\left(\left(1-D\_rgc\right)b\_rgc + D\_rgc\cdot K\_rg\left[m\_rg\right]\right) \\
& + \left(1-D\_rgbvc\right)\begin{pmatrix} D\_rgbv\left(\left(1-D\_rg\right)b\_rg \ + \ D\_rg\cdot K\_rg\left[m\_rg\right]\right) \\ + \ \left(1-D\_rgbv\right)\begin{pmatrix}\left(1-D\_rgv\right)\left(vl\_rg/party\right) \\ + D\_rgv\cdot K\_rg\left[m\_rg\right]\end{pmatrix}\end{pmatrix}
\end{aligned}
$$

where *D_rg* is as defined in expression (1); *party* is the number of party members; *D_rgbvc* is an indicator that equals one for charter boat trips with *party > 6* and zero otherwise; *D_rgc* is an indicator that equals one if $K\_rg \le b\_rgc$ and zero otherwise*; D_rgbv* is an indicator that equals one if $b\_rg \le (v\_rg/party)$ and zero otherwise; and *D_rgv* is an indicator that equals one if $K\_rg[m\_rg] \le (v\_rg/party)$ and zero otherwise. Note that in the event the bag limit equals the

effective vessel limit per contributor, the bag limit is assumed to bind. Also, note that the starting average keep per party member *K_rg*[*m_rg*] is conditional on any minimum size limit for red grouper. Similarly, expression (A3) replaces *K_rg*[*b_rg*] in (2) of the IR analysis and carries through expressions (3) to (6) to measure the effects all of the policies combined.

Results for the 2005 Regulatory Amendment Alternatives

The economic effects of the RA on private and charter boat anglers using 2003 and 2004 MRFSS data are shown in Table 4a through Table 7a.[3] The column headings are defined according to the listing for the IR results shown in Section 3. However, additional columns have been added for the RA analysis:

aff_rgm	Intercept trips affected by the red grouper minimum size limit
aff_rgv	Intercept trips affected by the red grouper vessel limit
aff_rgc	Intercept trips affected by the red grouper COI passenger limit
trips_rgmE	Estimated trips affected by the red grouper minimum size limit
trips_rgvE	Estimated trips affected by the red grouper vessel limit
trips_rgcE	Estimated trips affected by the red grouper COI passenger limit
party_rgmE	Estimated party members affected by the red grouper minimum size limit
party _rgbE	Estimated party members affected by the red grouper bag limit
party_rgvE	Estimated party members affected by the red grouper vessel limit
party_rgcE	Estimated party members affected by the red grouper COI passenger limit
party_gbbE	Estimated party members affected by the aggregate grouper bag limit
party_gbsE	Estimated party members affected by the aggregate grouper closed season

There are six additional columns that measure the number of intercepted and estimated trips affected by the minimum size, vessel and passenger limits. In addition, six new columns have

[3] Results are also available by mode for each year or in combination.

been added to measure the estimated number of party members[4] affected by each regulation. These estimates are calculated as the average number of party members per trip multiplied by the number of trips affected.

Please note that the same caveats described in Section 3 of the IR discussion also apply to the RA analysis. Additionally, dynamic effects are more likely with the RA as the policies are to be implemented over a two-year period. Biomass recovery following the implementation of the RA, for example, could contribute to increased catch rates. However, the allowable keep from increased in catch rates would be further constrained by the bag, vessel, passenger, and/or size limits. The net effect of each policy on angler welfare is difficult to predict without further information on system responsiveness and angler preferences for different dimensions of fishing quality. This is particularly true for minimum size limits (Woodward and Griffin 2003; Homans and Ruliffson 1999). To reiterate, caution should be used in interpreting the results as anything other than relative measures of the economic effects anticipated with each policy alternative.

Additional References

Homans, F.R., and J.A. Ruliffson. 1999. "The Effects of Minimum Size Limits on Recreational Fishing." *Marine Resource Economics* 14(1): 1-14.

Woodward, R.T. and W.L. Griffin. 2003. "Size and Bag Limits in Recreational Fisheries: Theoretical and Empirical Analysis." *Marine Resource Economics* 18(3): 239-262.

[4] Party members are defined as the average number of anglers by year/state/mode/wave strata who participated on snapper-grouper targeted trips.

Table 1a. Proposed Management Alternatives for the Recreational Red Grouper Fishery: 2005 Regulatory Amendment*

Action	Alternative	Red Grouper				Grouper	
		Minimum Size Limit (TL")	Bag Limit (fish)	Vessel Limit (fish)	Passenger Limit (fish/pass.)	Bag Limit (fish)	Closed Season
1. Red Grouper Management Alternatives	1	20	2	-	-	5	None
	2	20	1	3	-	5	None
	3	22	2	-	-	5	None
	4a	20	1	-	-	5	Aug
	4b	20	1	-	-	5	Apr-May
	5	20	1	-	-	5	Feb-Mar**
	6	21	1	-	-	5	None
	7	20	1	3	0.5***	5	None
2. Aggregate Grouper Management Alternatives	2	20	2	-	-	4	None
	3	20	2	-	-	3	None
	4	20	2	-	-	2	None

*The alternatives are based on a list distributed on 8/15/2005 by Stu Kennedy at NMFS/SERO.
**The closed season is for red, gag, and black grouper from February 15 to March 15. However, this policy is modeled for all grouper for the entire months of February and March.
***The policy of two fish per paying passenger has been converted to an effective fish per passenger limit.

Table 2a. Disposition of the Red Grouper Recreational Keep in the Gulf of Mexico: 2003-2004

	Target Snapper-Grouper		Catch Red Grouper		
	No	Yes	No	Yes	Total
			--Keep per Trip--		
N	22,970	1,864	22,494	2,340	24,834
Sum	3,168	1,105	0	4,273	4,273
Mean	0.14	0.59	0	1.83	0.17
Std	1.03	1.95	0	3.26	1.13
Min	0.00	0.00	0	0.00	0.00
Max	34.00	37.00	0	37.00	37.00
			--Party Members--		
N	22,970	1,864	22,494	2,340	24,834
Sum	63,595	7,379	59,607	11,367	70,974
Mean	2.77	3.96	2.65	4.86	2.86
Std	1.71	2.69	1.53	2.90	1.83
Min	1.00	1.00	1.00	1.00	1.00
Max	28.00	31.00	31.00	28.00	31.00
			--Keep per Party Member--		
N	22,970	1,864	22,494	2,340	24,834
Sum	654	256	0	910	910
Mean	0.03	0.14	0.00	0.39	0.04
Std	0.21	0.45	0.00	0.69	0.24
Min	0.00	0.00	0.00	0.00	0.00
Max	7.50	7.40	0.00	7.50	7.50

Source: MRFSS Intercepts for Private and Charter Boat Anglers (2004 as of 5/2005)

Table 3a. Private and Charter Boat Effort in the Gulf of Mexico, 2003-04, Waves 1 - 6

	2003	2004	2003	2004
	--Intercepts--		*--Estimates--*	
Red Grouper Catch Trips	989	1,351	673,756	913,508
Grouper Bag Catch Trips	2,011	2,364	1,688,558	1,863,178
Snapper-Grouper Catch Trips	3,388	3,715	3,229,960	3,293,032
Red Grouper Target Trips	59	151	53,189	142,641
Grouper Bag Target Trips	285	383	305,148	388,796
Snapper-Grouper Target Trips	869	995	850,511	993,128
Total Trips	12,000	12,834	14,801,369	15,014,725
Red Grouper Catch Party Members			1,920,900	2,666,896
Grouper Bag Catch Party Members			4,470,375	5,145,766
Snapper-Grouper Catch Party Members			8,334,719	8,872,969
Red Grouper Target Party Members			136,758	372,567
Grouper Bag Target Party Members			750,165	977,541
Snapper-Grouper Target Party Members			2,314,986	2,641,881
Total Party Members	34,049	36,925	35,597,008	36,833,400

Source: MRFSS (2004 as of 5/2005) and Author's calculations.

Table 4a. Snapper-Grouper Targeted MRFSS Trips Affected by the Regulatory Amendment: Private and Charter Boats

Scenario	aff_rgm	aff_rgb	aff_rgv	aff_rgc	aff_gbb	aff_gbs
			--2003--			
Alt1	32	4	0	0	4	0
Alt2	32	7	10	0	4	0
Alt3	76	3	0	0	2	0
Alt4a	32	16	0	0	4	95
Alt4b	32	16	0	0	4	200
Alt5	32	16	0	0	4	71
Alt6	63	12	0	0	3	0
Alt7	32	7	10	3	4	0
AGBL_1	32	4	0	0	4	0
AGBL_2	32	4	0	0	12	0
AGBL_3	32	4	0	0	23	0
AGBL_4	32	4	0	0	44	0
			--2004--			
Alt1	25	11	0	0	12	0
Alt2	25	19	42	0	12	0
Alt3	104	5	0	0	8	0
Alt4a	25	41	0	0	12	118
Alt4b	25	41	0	0	12	271
Alt5	25	41	0	0	12	75
Alt6	77	32	0	0	9	0
Alt7	25	19	42	10	12	0
AGBL_1	25	11	0	0	12	0
AGBL_2	25	11	0	0	23	0
AGBL_3	25	11	0	0	41	0
AGBL_4	25	11	0	0	62	0

Table 5a. Estimated Snapper-Grouper Targeted Trips Affected by the Regulatory Amendment: Private and Charter Boats

Scenario	trips_rgmE	trips_rgbE	trips_rgvE	trips_rgcE	trips_gbbE	trips_gbsE
			--2003--			
Alt1	17,995	782	0	0	714	0
Alt2	17,995	8,835	2,096	0	714	0
Alt3	39,020	613	0	0	390	0
Alt4a	17,995	10,698	0	0	714	113,207
Alt4b	17,995	10,698	0	0	714	159,479
Alt5	17,995	10,698	0	0	714	70,130
Alt6	32,867	8,417	0	0	546	0
Alt7	17,995	8,835	2,096	614	714	0
AGBL_1	17,995	782	0	0	714	0
AGBL_2	17,995	782	0	0	3,317	0
AGBL_3	17,995	782	0	0	8,349	0
AGBL_4	17,995	782	0	0	26,722	0
			--2004--			
Alt1	18,093	9,049	0	0	4,618	0
Alt2	18,093	22,523	15,144	0	4,618	0
Alt3	60,965	5,440	0	0	3,064	0
Alt4a	18,093	30,886	0	0	4,618	163,212
Alt4b	18,093	30,886	0	0	4,618	235,892
Alt5	18,093	30,886	0	0	4,618	75,287
Alt6	44,655	25,086	0	0	3,248	0
Alt7	18,093	22,523	15,144	2,134	4,618	0
AGBL_1	18,093	9,049	0	0	4,618	0
AGBL_2	18,093	9,049	0	0	12,263	0
AGBL_3	18,093	9,049	0	0	19,160	0
AGBL_4	18,093	9,049	0	0	35,419	0

Table 6a. Estimated Snapper-Grouper Targeted Party Members Affected by the Regulatory Amendment: Private and Charter Boats

Scenario	party_rgmE	party_rgbE	party_rgvE	party_rgcE	party_gbbE	party_gbsE
			--2003--			
Alt1	63,499	3,647	0	0	3,231	0
Alt2	63,499	21,316	10,191	0	3,231	0
Alt3	140,720	2,823	0	0	1,799	0
Alt4a	63,499	30,315	0	0	3,231	324,188
Alt4b	63,499	30,315	0	0	3,231	468,804
Alt5	63,499	30,315	0	0	3,231	165,302
Alt6	115,363	23,438	0	0	2,407	0
Alt7	63,499	21,316	10,191	2,968	3,231	0
AGBL_1	63,499	3,647	0	0	3,231	0
AGBL_2	63,499	3,647	0	0	11,885	0
AGBL_3	63,499	3,647	0	0	27,241	0
AGBL_4	63,499	3,647	0	0	74,647	0
			--2004--			
Alt1	53,318	25,590	0	0	15,166	0
Alt2	53,318	56,727	54,972	0	15,166	0
Alt3	195,742	14,431	0	0	10,475	0
Alt4a	53,318	87,388	0	0	15,166	435,265
Alt4b	53,318	87,388	0	0	15,166	654,276
Alt5	53,318	87,388	0	0	15,166	183,824
Alt6	140,586	70,981	0	0	11,237	0
Alt7	53,318	56,727	54,972	10,319	15,166	0
AGBL_1	53,318	25,590	0	0	15,166	0
AGBL_2	53,318	25,590	0	0	36,607	0
AGBL_3	53,318	25,590	0	0	62,438	0
AGBL_4	53,318	25,590	0	0	106,996	0

Table 7a. Estimated Reduction in Snapper-Grouper Keep and Value on Snapper-Grouper Targeted Trips from the Regulatory Amendment: Private and Charter Boats

Scenario	est_sgr	val_sgr
	--2003--	
Alt1	38,322	139,704
Alt2	61,217	234,487
Alt3	78,822	277,920
Alt4a	102,613	398,448
Alt4b	200,567	745,570
Alt5	128,143	506,106
Alt6	76,507	277,506
Alt7	62,531	239,930
AGBL_1	38,322	139,704
AGBL_2	52,617	198,884
AGBL_3	78,495	306,022
AGBL_4	141,286	565,973
	--2004--	
Alt1	70,206	275,711
Alt2	158,027	639,290
Alt3	169,934	661,247
Alt4a	301,896	1,222,603
Alt4b	351,420	1,388,743
Alt5	168,907	680,366
Alt6	163,201	642,093
Alt7	163,943	663,781
AGBL_1	70,206	275,711
AGBL_2	105,123	420,266
AGBL_3	160,808	650,671
AGBL_4	255,552	1,042,122

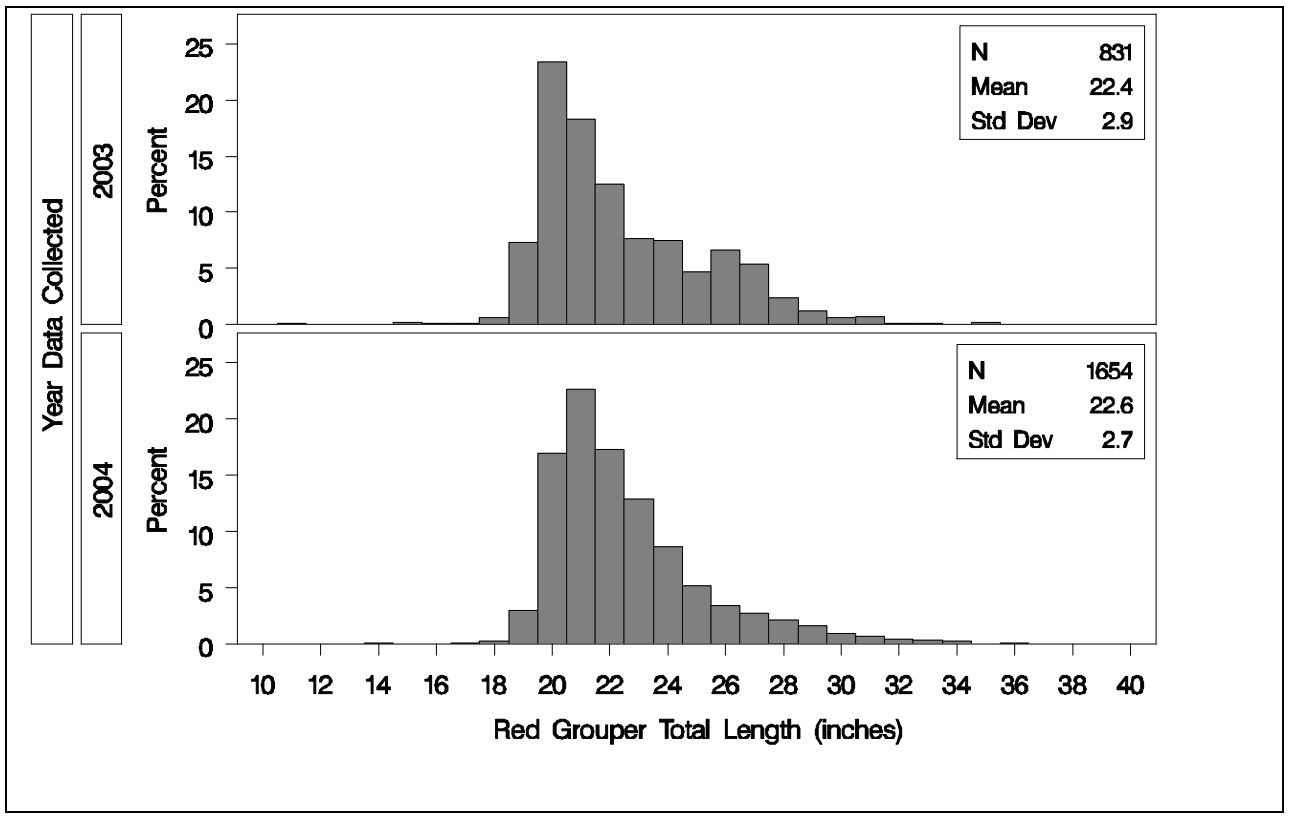

Figure 1a. Distribution of Red Grouper Lengths in the Gulf of Mexico: MRFSS 2003 and 3004